BRUNSWICK OUTER BAR, GEORGIA.

LETTER

FROM

THE ACTING SECRETARY OF WAR.

TRANSMITTING,

With a letter from the Chief of Engineers, copy of the report of the preliminary examination and survey of Brunswick Outer Bar, Georgia.

JANUARY 5, 1892.—Referred to the Committee on Rivers and Harbors and ordered to be printed.

WAR DEPARTMENT,
Washington, December 19, 1891.

SIR: I have the honor to inclose herewith a letter from the Chief of Engineers, dated the 18th instant, together with copies of reports from Capt. O. M. Carter, Corps of Engineers, dated October 8, 1890, and December 10, 1891, of a preliminary examination and survey of "Brunswick Outer Bar, Georgia, to determine the feasibility and cost of deepening the same to 26 feet at ordinary high water," made by him in compliance with the provisions of the river and harbor act of September 19, 1890.

Very respectfully,

L. A. GRANT,
Acting Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 18, 1891.

SIR: I have the honor to submit herewith copies of reports, dated October 8, 1890, and December 10, 1891, respectively, upon preliminary examination and survey, with four maps, of "Brunswick Outer Bar, Georgia, to determine the feasibility and cost of deepening the same to 26 feet at ordinary high water," made by Capt. O. M. Carter, Corps of Engineers, in compliance with provisions of river and harbor act approved September 19, 1890.

The proposed improvement contemplates a channel across the outer bar, opposite the entrance to St. Simon Sound, 300 feet wide and 26 feet deep at mean low water, to be obtained by the construction of two jetties and by dredging, the jetties extending eastwardly from St. Simon and Jekyl islands to points outside the bar, the least distance between the two jetties being 5,000 feet. The total cost of this work, in round numbers, is estimated at $2,700,000.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. L. A. GRANT,
Acting Secretary of War.

PRELIMINARY EXAMINATION OF BRUNSWICK OUTER BAR, GEORGIA, TO DETERMINE THE FEASIBILITY AND COST OF DEEPENING THE SAME TO 26 FEET AT ORDINARY HIGH WATER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., October 8, 1890.

GENERAL: In compliance with Department letter dated September 20, 1890, I have the honor to submit the following report of a preliminary examination of "Brunswick Outer Bar, Georgia, to determine the feasibility and cost of deepening the same to 26 feet at ordinary high water."

Brunswick is situated upon the east coast of Georgia, about 60 miles by the coast line south of the Savannah River. The outer harbor comprises the anchorages in Brunswick River and St. Simon Sound, and "Brunswick Outer Bar" is assumed to mean the ocean bar which obstructs the entrance to St. Simon Sound.

The earliest reliable survey of that locality known to me is one made by the United States Coast Survey between 1856 and 1860. The bar, which extends in a horseshoe shape across the entrance from St. Simon Island on the north to Jekyl Island on the south, has not changed much in location or general direction since the time of that survey. The channel across it has, however, shoaled greatly, the minimum mean low-water depth, which was 15 feet at the time of the former survey, being at the present time not more than 11½ feet. The outer 18-foot curve has not moved appreciably seaward, but the navigable bar channel has shifted its position toward the south, the 6-foot curve of the north breakers having moved southward about one-half of a mile in the last thirty years. Some slight shoaling has also taken place in the deep pocket inside of the crest of the bar, one sand spur, directly in the channel, and with a depth of water less than 18 feet at mean low tide, having moved shoreward about three-quarters of a mile. Detailed information concerning the bar can be given only after a survey of the locality has been made.

The importance of the city of Brunswick as a seaport has increased with remarkable rapidity during the past ten years. The population has increased from less than 3,000 in 1880 to about 12,000 in 1890. Taxable property has increased during the same period from $1,300,000 to $6,000,000. The naval stores business, which was first begun there in 1875, reached a value of over $1,000,000 in 1889. The annual timber shipments increased during the same period from 37,000,000 feet to over 100,000,000. Cotton shipments of 4,000 bales in 1884–'85 reached nearly 175,000 bales in 1889–'90. Between 80 and 90 per cent of the total trade of Brunswick is dependent upon water carriage. Two railroads terminate at that point, the East Tennessee, Virginia and Georgia reaching, with its connections, the North and Northwest, and the Brunswick and Western extending into Georgia, Alabama, and beyond.

The following lines of steamers are established:

Brunswick to New York, one per week.
Brunswick to Savannah, two per week.
Brunswick to river points, fourteen per week.

Besides those a large fleet of foreign and coastwise sail and steam vessels engage in the Brunswick trade, which consists chiefly of cotton, timber, lumber, and naval stores.

The shoaling which has taken place on the bar, and which prevents vessels of large carrying capacity from entering the harbor, seriously threatens the commerce of the port and retards its further development.

I respectfully invite attention to the appended letters of the mayor of the city and the president of the Board of Trade, and of the president of the Brunswick Terminal Company.

For all the reasons stated I am of the opinion that the harbor is worthy of improvement. The estimated cost of a survey on which to base a plan and estimate of improvement is $6,000.

It is imperative that the calm weather usually prevailing at this season of the year be taken advantage of, lest the estimated cost be greatly exceeded and the completion of the survey much delayed. The survey should be begun at once.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. William P. Craighill, Corps of Engineers, Division Engineer, Southeast Division.)

[Second indorsement.]

U. S. ENGINEER OFFICE,
Baltimore, Md., November 20, 1890.

Respectfully returned to the Chief of Engineers. In view of the facts and reasons set forth in the report of the local engineer it is considered that the locality is worthy of improvement.

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.

LETTER FROM THE MAYOR OF THE CITY OF BRUNSWICK AND THE PRESIDENT OF THE BOARD OF TRADE.

BRUNSWICK, GA., *October 7, 1890.*

DEAR SIR: In answer to your inquiry as to the commercial reasons in favor of the deepening of the outer bar of Brunswick, we have to say that the wonderful progress of Brunswick from 1880 to 1890 from a population of 2,981 in 1880, to a population of over 12,000 for 1890; the increase in the lumber business from 37,000,000 feet in 1875, to over 100,000,000 feet; the increase in the cotton business from 4,000 bales for the season of 1884–'85, to 162,930 bales for the season of 1889–'90; the increase in naval stores from nothing in 1874 to over $1,000,000 for the season of 1889; the creation within the past three years of a new business rapidly growing in importance in the shipment of cross-ties from this port, which loads vessels to their dead-weight capacity, indicate the importance of deepening the outer bar for the reason that the draft of vessels recently constructed and in course of construction is much greater than at any time prior to 1885, and for the reason that charterers can obtain deeper-draft vessels at a much lower rate per ton than the lighter-draft vessels, and having a wider range for charters if enabled to charter deep-draft as well as light-draft vessels, are enabled to procure at all times better charter parties and better rates of freight.

The East Tennessee, Virginia and Georgia Railroad Company has its ocean terminus at Brunswick, and touches every important commercial city in the interior, whether with its main line and branches or with connections made by traffic contract.

The Brunswick and Western Railroad Company, a part of the Plant system of railroads, through the Alabama Midland Railroad, constructed from Bainbridge to Montgomery, and rapidly being extended from Montgomery to Tuscaloosa, and these with the Illinois Central gives us another important line of western and northwestern connections. Both these railroad systems traverse the great iron and coal belt of the South, and reach into and connect with the great northwestern systems traversing the grain section of the West and Northwest, and also connect with the southwestern system of railroads.

The East Tennessee, Virginia and Georgia Railroad Company's terminal at Brunswick is upon 22 feet of water at its wharves at ordinary low water, and there is in the channel of Turtle River for its whole distance to the sea more than 22 feet which can be carried to the bar, at which point but 11½ feet at ordinary mean low water is shown by the last United States Coast Survey chart. While it is probable that by the changes which have occurred in the location of the channel deeper water can at times be obtained over the bar, yet the railroads terminating at this point, the people interested in its commerce and the people in the territory tributary to Brunswick are compelled to seek other ports at a greater expense than they would be put to if this obstruction was removed.

Another view of this matter which our Board desires to present for your consideration is that Brunswick is in the extreme curvature of the South Atlantic coast; it is nearer than any other South Atlantic port to all interior points in the South, in the West, in the Northwest.

We desire to present for your consideration the fact that our harbor by the formation of the islands of St. Simon and Jekyl is absolutely landlocked; and that, as can be seen by a mere glance at the Coast Survey chart of our harbor, the arms of the sea which create it give us 37 miles of water front easily and cheaply available with deep water close in shore. The wonderful growth of the South for the past ten years, the tremendous investments in productive industries of various character, have vastly increased the freight product which must find outlets to the markets of the world. The vast amount of money invested in the past four years in productive industries of the South—in 1888, $161,000,000; in 1889, $229,000,000—must increase still further the enormous freight product shown by the figures of 1889 and 1890, thus indicating the national importance of an improvement of this character as creating an additional outlet for the vast products of the interior of the South, as well as an additional outlet for the vast products of the Northwest and West which during the winter months cannot find adequate outlet over the great trunk lines of the North by reason of blockades of ice and snow, and can find outlet over lines never thus obstructed, with easy grades to this port by shorter lines of haul, an advantage not only applicable to the grain and flour of that section, but also applicable to the increasing export of cattle.

There has been, within the last three years, invested in Brunswick, of northern capital $3,250,000, and if the outer bar was deepened to 26 feet at mean high water there would be a certainty of future investments in terminal facilities and commercial business of various kinds of a magnitude commensurate with the enlarged business which would be at once created at this point.

Respectfully submitted.

C. DOWNING,
President Board of Trade.
J. J. SPEARS,
Mayor City of Brunswick, Ga.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

LETTER OF MR. A. F. CHURCHILL, PRESIDENT AND GENERAL MANAGER OF THE BRUNSWICK TERMINAL COMPANY.

BRUNSWICK, GA., *October 7, 1890.*

DEAR SIR: This company is laboring under a great disadvantage in chartering vessels, owing to the shoal water on the bar.

Our neighboring ports that have more water on the bar than we have on ours can get cheaper ships than we can. I was offered a ship to-day at 75 cents per register ton less than I am compelled to pay for suitable draft vessels for this port.

This means prohibition for the exports to the port of Brunswick, and compels all interior markets naturally tributary to the port of Brunswick to ship their goods to other ports, not only at an increased cost to them, but at a loss of the business to Brunswick.

You can readily see the disadvantage under which we are laboring; can not the remedy be applied, and put the port of Brunswick on equal footing, equal rates, and equal draft of water on the bar with our neighboring ports?

Yours, very truly,

A. F. CHURCHILL,
President and General Manager.

Lieut. O. M. CARTER,
Corps of Engineers, U. S. A.

SURVEY OF BRUNSWICK OUTER BAR, GEORGIA, TO DETERMINE THE FEASIBILITY AND COST OF DEEPENING THE SAME TO 26 FEET AT ORDINARY HIGH WATER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., December 10, 1891.

GENERAL: In accordance with the requirements of section 17 of the river and harbor act of September 19, 1890, and instructions from the Chief of Engineers, dated November 21, 1890, I have the honor to submit herewith my report upon the survey of "Brunswick Outer Bar, Georgia, to determine the feasibility and cost of deepening the same to 26 feet at ordinary high water," together with a project for its improvement and an estimate of the cost of the same.

A brief description of the aim of the proposed improvement and some facts relating to its commercial importance are given in my report upon the preliminary examination, dated October 8, 1890, to which I respectfully refer.

The survey of the bar was made under my direction by my assistant, Lieut. Thomas H. Rees, Corps of Engineers, U. S. Army, between December, 1890, and June, 1891. His very complete report, submitted this date, renders unnecessary any further discussion of the subject, and is transmitted herewith as a part of my report.

The project of improvement, proposed therein was prepared under my direction, and is approved.

The estimated cost of the improvement which, in round numbers, is $2,700,000, supposes that money is regularly and adequately supplied. Without this the cost of the work will be largely increased and its success rendered doubtful.

That advantage may be taken of experience gained in the work, wide discretion should be allowed the engineer in charge, especially as to the form of the jetty cross section and the order in which work is to be done.

Respectfully submitted.

O. M. CARTER,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF LIEUT. THOMAS H. REES, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., December 10, 1891.

CAPTAIN: I have the honor to submit herewith my report on a survey of Brunswick Outer Bar, made pursuant to your orders of December 8, 1890, together with a project for its improvement, with a view of obtaining a channel 26 feet in depth at mean high water, and an estimate of the cost thereof.

I will first describe the methods and results of the survey, and then give a general description of the harbor and its commerce, and the plan proposed for its improvement. Your orders of December 8, 1890, and verbal instructions of the same date, directed a complete hydrographic survey of Brunswick Outer Bar and the adjacent channels and shoals, to include—

(1) A triangulation covering the shore area within the limits of the survey.

(2) The topography of the shores within the same limits.

(3) The determination of azimuths by observations on a circumpolar star, and of magnetic declination by compass readings.

(4) Soundings thoroughly covering the bar and adjacent channels and shoals between the shore and the outer 24-foot mean low-water curve.

(5) Tidal observations at the following points, viz, at Ocean Pier, at some point on Brunswick River, at the city of Brunswick, and at the East Tennessee, Virginia and Georgia Railroad wharf on Turtle River.

(6) Current observations for velocities and directions at necessary points.

(7) Determination of the character of the bottom.

(8) The plotting of maps and diagrams showing the results of the survey.

The necessary instruments and boats were obtained from your office, and the steam launch, with a complete outfit for the survey, reached Brunswick December 16.

A party, consisting of 1 assistant engineer, 2 surveyors, 1 rodman, 1 recorder, 1 master of launch, 1 engineer, 1 leadsman, 1 cook, 1 or more boatmen and laborers, as needed, was assembled and quartered on St. Simon Island, and active operations were begun on the 19th.

BASE LINE.

A suitable location for a base line was found across the southern end of St. Simon Island. The line was cleared of trees and brush, and stout, square stakes were driven exactly on line and a little less than 100 feet apart. A square of tin, marked with a fine-lined cross (+) was tacked to the top of each stake. A 100-foot steel tape was used in the measurements. A number of narrow open boxes, from 15 to 20 feet long and 5 inches high, was prepared, their aggregate length being a little less than 100 feet. These were blocked up end to end in a straight line between two of the stakes, the extreme ends being exactly even with the tins on the tops of the latter. The tape was stretched in the line of boxes and left there with a Fahrenheit thermometer until a uniform temperature should be attained. The front end of the tape was then held rigidly at some even division and the tape stretched by a 12-pound pull at the rear end, applied by a spring balance, and this end of the tape was read to the nearest one-thousandth of a foot. The temperature was recorded at the same time. The tape was thus protected from the wind and from the direct rays of the sun; it was maintained in a straight line without sag, and its temperature was closely determined. Each reading was taken twice to avoid errors, and the whole line was measured twice. No attempt was made to keep the tape horizontal during a measurement, but the difference in elevation of the stakes was found by leveling and the measured distance reduced to the horizontal distance.

The form of record was as follows:

Base line, December 23, 1890.

[Observers: Rees, Paret.]

Station.	Rear end.	Front end.	Difference in elevation of stakes.	Horizontal length.	Temperature, F.
	′	′	′	′	°
0 to 1	0.225	99.4	0.54	99.1734	64
1 to 2	0.295	99.4	0.69	99.1025	61
(*)	(*)	(*)	(*)	(*)	(*)
44 to 45	0.324	44.6	2.71	44.1930	66
Measured length				3,984.7431	

The coefficient of expansion of the steel tape used for 1 foot and 1° F. is 0.00000692, and the tape is standard length at 46.6° F. The mean temperature during this measurement was 64.6°, hence 46.6 — 64.6 equals (—) 18.0°, and,

	Feet.
(—) 18 × 3984.74 × .00000692 =	(—) 0.4963
Measured length =	3, 984.7431
Corrected length =	3, 984.2468
The second measurement gave the following corrected result	3, 984.2822
And a consequent mean of	3, 984.2645

With a probable error of 1 unit in about 225,000. The standard referred to is that of the Mississippi River Commission. At each end of the base an iron rod about 5 feet long was sunk flush with the surface of the ground, and over them the triangulation stations were erected.

TRIANGULATION.

Besides the stations at east base and west base, five others were established. The tower of the Hotel St. Simon served admirably as one station. The light-house tower gave another. An unused beacon on the mainland, opposite the entrance, was used as a station, and two other stations were erected on Jeykl Island at its northern point, and at a point about 2 miles down the beach. This southernmost point and hotel are 6,890.8 yards apart, and afforded an excellent base line for the location of offshore soundings. They were, in fact, selected with that object in view. The seven stations were connected by a system of five triangles, the angles of which were measured by the method of repetitions. From eleven to thirty readings of each angle were taken. The errors of closure of the triangles were

$$+04.0'' - 01.7'' + 08.2'' - 03.9'' \text{ and } +16.4''.$$

This last error occurred in a large ill-shaped triangle, one station of which was very indistinct and difficult to read accurately. The theodolite used in triangulation read only to 20 seconds of arc; therefore, the above errors are as small as could be expected. The light-house could not be occupied centrally by the instrument, and the angles were therefore measured at an eccentric point and reduced to the center by the formula

$$C = O + \frac{\sin(O+y)}{D \sin 1''} - \frac{r \sin y}{G \sin 1''},$$

in which C is the required angle and O is the measured angle.

None of the triangles used were very fair-shaped, but better ones could not be obtained without using several additional points and erecting stations from 30 to 50 feet high, which the requirements of the survey did not warrant.

TOPOGRAPHY.

The topography of the shore line, including high and low water lines, and the principal features in the vicinity of the shore, were obtained by running stadia lines, beginning at and closing on triangulation stations. This work was mostly performed in January, but it was subsequently found that several storm tides had materially altered the conformation of the shore line; and in order to determine the extent of this alteration, high and low water lines were again located in May, and the different positions of these lines are shown on the final map of the survey. There were in all about 12 miles of stadia lines run, and 113 stations occupied. There were also 14 cross sections of the beach taken.

AZIMUTH.

The line, the astronomical azimuth of which was determined, was east base, hotel. It happened that a time could be selected for the observations, when Polaris reached western elongation just after sunset, so that while Polaris was visible, there was still sufficient light to see the cross hairs and the mark at station "hotel" without illuminating either. The terrestrial mark, the point of a lightning rod at the apex of the hotel tower, was therefore the same as that observed in triangulation, and its size and distance were such that it was not found necessary to change the focus of the instrument after observing the star. An excellent set of observations was thus obtained, giving the azimuth of the line east base, hotel, measured from the south point round by the west equal to 230° 55′ 04″.

In this connection it may be stated that the same station (east base) and mark (hotel) were used in taking observations for magnetic declination. After a large number of observations for this purpose had been taken with Brandis Transit, No. 1054, it was found that the readings did not agree at all well, and investigation showed that the needle was so sluggish that it could not be set accurately, a change of several minutes of arc occurring after a disturbance of the needle. The Gurley Transit was therefore used, after thorough adjustment, in a new series of observations, and the result showed that it was much better suited to the purpose than the Brandis instrument. The mean of thirteen sets of observations, each set containing five readings, gave the magnetic azimuth of the line east base, hotel, measured from

	° ′ ″
the south point round by the west=	229 25 27
True azimuth, as above=	230 55 04
Hence magnetic declination, east=	1 29 37

SOUNDINGS.

All soundings were taken from the steam launch. An 8-pound lead was used in depths not exceeding 40 feet, and a 12-pound one in greater depths. The lead line was kept constantly wet and was compared before and after each day's work, with the steel tape. The pull exerted on the lead line during sounding, at the speed usually maintained, was found, with a spring balance, to be about 12 pounds; and this same pull was always applied in stretching the line during comparisons with the tape. The soundings were located at one-minute intervals by angles from two transits at triangulation stations on shore, selected with reference to giving good angles of intersection over the area to be sounded. This gave from two to six intermediate soundings to be placed by equal spacing between the located points. A chronometer was used on the launch for keeping time, and the watches of the transitmen were compared with the chronometer before and after each day's work. The sounding to be located was indicated to the transitman by a signal on the launch given at the instant the lead line became vertical on the sounding nearest the end of the even minute. The signal used was cylindrical in form, about 18 inches in diameter and 3 feet high, arranged to slide centrally on a vertical pole and to collapse like a bellows when dropped. It was raised and dropped by means of halyards.

Two sets of lines of soundings were run, one set running off and on shore approximately perpendicular to the shore line, and the other set crossing the first nearly at right angles. The offshore soundings were so distant as to render it impossible to see ordinary shore ranges; therefore, in order to cover the ground uniformly, the following method was adopted: The light-house tower on St. Simon Island was used as a signal station, and the offshore lines of the first set radiated from this point. The lines were established by the setting of a transit located on the light-house tower, and the launch was kept as nearly as possible on the cross hairs of the instrument by the motions of a large signal flag. When the flag was displayed on the north side of the tower the launch would incline gradually in that direction; as she approached the proper line, the flag would be raised to a vertical position and the launch would be straightened out on her course. The opposite motion of the flag moved the launch to the southward and she could thus be kept within a few feet of the true line.

The inshore lines of the first set were run on ranges established on shore from 400 to 500 feet apart. The lines of the second set, crossing the first, were run from an anchored range boat carrying a large flag, which was always kept by the launch in range with the most distant headland visible. After each line was completed, the range boat was moved 400 feet seaward, which spaced the lines at that interval. The headland used as the rear range point was so distant that the divergence of the lines was scarcely perceptible. The total number of soundings plotted was 36,095 and the number of located soundings was 8,176. There were in addition to these 1,062 soundings and 251 locations that were missed by one or both transits on account of rain, fog, or haze. The outer soundings were so distant that only on an exceptionally clear day could the transitman see the launch or her signals, and, under the most favorable circumstances, she was invisible to the naked eye more than half the time.

TIDAL OBSERVATIONS.

Tide gauges were established at Ocean Pier, St. Simon Island; at Quarantine Wharf, Brunswick River; at the Brunswick and Western Railway wharf, city of

Brunswick; and at the East Tennessee, Virginia and Georgia Railway wharf, on Turtle River.

At the Ocean Pier a Stierle self-registering gauge was established December 20, 1890, and maintained till June 3, 1891, giving a record of the times and heights of 297 high and low waters. A similar self-registering gauge was established at the Brunswick and Western Railway wharf, Brunswick, on January 5, 1891, and maintained until May 12, 1891, giving a record of the times and heights of 166 high waters and 152 low waters. This gauge did not work satisfactorily until some necessary alterations and repairs were effected, and a portion of the record during the above period was therefore lost. At the Quarantine wharf, Brunswick River, a staff gauge was read day and night from March 6 to April 25, 1891. The times and heights of 97 high waters and 97 low waters were recorded. At the East Tennessee, Virginia and Georgia Railway wharf, on Turtle River, day readings of high and low water on a staff gauge were begun March 19; night readings were begun April 8, and both were continued until May 19, 1891. There were recorded during this period the times and heights of 102 high waters and of 98 low waters.

LEVELING.

Bench marks were established near all gauges and connected by lines of levels, and the elevation of each bench mark with reference to mean low-water level on the adjacent gauge was determined. The distance across the Sound from St. Simon Island to the mainland is so great that level readings over the whole distance would have been unreliable, owing to the effect of refraction. Two pile stations were therefore constructed on shoals in the sound, dividing the distance into three equal parts of about 2,300 feet each. This gave level sights in opposite directions over equal spaces of water, and eliminated to a great extent the effects of curvature and refraction. In leveling across the marshes from St. Simon Sound to Brunswick and from Brunswick to the Quarantine gauge it was necessary to construct a station at each instrument point on account of the yielding and tremulous nature of the marsh soil. Stout scantlings, about 8 feet long, were sunk into the marsh until their tops were a few inches above the surface. Three of these at each station served as points of support for the tripod of the level, and one was placed at each turning point to support the level rod. The length of sight was uniformly 600 feet, measured by chaining. The line across the sound on the pile stations was leveled three times; that from the sound to Brunswick, twice; from Brunswick to the East Tennessee, Virginia and Georgia Railroad wharf, four times, and from Brunswick to Quarantine, three times. A single run over these lines covered a distance of about 12 miles, and the aggregate length of all the lines run was about 32 miles.

CURRENT OBSERVATIONS.

Current meters and submerged floats were both used in the determination of the velocities and directions of tidal currents. The meters having been repaired since previous ratings, it was necessary to rerate them, and an excellent place for this purpose was found in a small artifical pond near the city of Brunswick, filled with salt water from the sound by means of flood gates. It is 280 feet long, 100 feet wide, and from 4 to 6 feet deep. The banks are low, level, and free from brush and trees. A base line 200 feet long was laid off at one side and parallel ranges established at its ends. A large bateau was carried to the pond and fitted up in such a manner that 2 meters could be rated at the same time. A piece of scantling was lashed across the bow of the boat and its ends pierced by vertical holes 2.5 feet outboard. Iron rods passing through these holes, and held by washers, carried the meters at their lower ends at a depth of about 1.5 feet from the surface. The meters turned freely on the rods, and were connected in the usual manner with the batteries and electric registers in the boat. The boat was connected by long bow and stern lines with reels at the ends of the pond, by means of which she was hauled forth and back. The record was kept only during the forward trip. A uniform predetermined velocity was acquired before the boat reached the first cut-off range. When this range was crossed the registers were started and the chronometer read to the nearest half second. When the second range was reached the registers were stopped and the chronometer again read. During the return trip the meters and connections were examined and the registers read and adjusted, if necessary. The velocities during the trials ranged between 0.6 of a foot and 7.6 feet per second. Uniform velocities during the several runs were maintained by timing the revolutions of the reel. In this manner 4 meters were rated, viz, 2 of Buff & Berger's Ellis meters, marked respectively "A" and "B," and 2 Stackpole propeller meters, marked respectively "1" and "2." They were taken in various combinations of two in order to cross-check the results. Their constants were determined graphically by plotting the individual results, and analytically by means of the equations,

$$a=\frac{\Sigma(x-x_0)(y-y_0)}{\Sigma(x-x_0)^2},$$

and

$b=y_0-x_0 a$, in which a and b are the constants in the equation;
$y=ax+b$;
x=revolutions per second;
y=velocity in feet per second.

The resulting values of the constants are shown in the following table:

Meter.	Number of runs.	Value of A.	Value of b.
Ellis A	47	3.399	0.102
Ellis B	55	3.539	0.081
Stackpole, No. 1	36	1.719	0.193
Stackpole, No. 2	29	2.312	0.079

The floats used in addition to the meters in determining velocities and directions of currents were submerged floats made of open tin cans about 6 inches in diameter and 8 inches high, connected by a cord with a surface float of cork, 4 inches square and 1 inch thick, carrying a little staff and flag, to render it visible to a transit instrument on shore. An attempt was made to gauge the tidal flow through the gorge at the entrance to the sound by using the meters, but the great depth of the water and strength of the currents made it impossible, with the appliances available, to get any satisfactory results. The depths at the points occupied were over 80 feet at mean low water, and the bottom was soft and shifting. The difficulties encountered were dragging of anchors, sagging of the stand lines, and imperfect insulation of the lead wires, which became apparent when great lengths were required. Submerged floats run at mid depth were therefore substituted for the meters in the deep water of the entrance, and they were also used at other points when it was too rough for meter work. This work was done during the month of May, and there were but thirteen days on which observations could be made, owing to the winds and heavy seas that prevailed during that period. There were in all thirteen different positions occupied, as follows: Three on the cross section at the entrance, two in the flood channel near St. Simon Island, one near the northerly slough channel, and two in the southerly slough channel about half way between the shore and the bar; two at the bar, and three in deep water outside of the bar. Entire tides could not be observed at all points, owing to interruptions of the work by bad weather. The ebb observations are fairly complete, the flood observations only partial.

RESULTS.

The principal results rendered by the tidal observations and leveling have been platted so as to show, for each point at which observations were made—

I. Curves of semimenstrual inequality of times of high and low water.
II. Curves of semimenstrual inequality of heights of high and low water.
III. Mean tidal curves.
IV. Lines of high and low water.
V. Mean ebb and flood surface slopes.

In diagrams III, IV, and V all heights are referred to the level of mean low water at Ocean Pier. At Ocean Pier the record of tides extended over a period of about five months, and the results are therefore close approximations to the true values. At the Brunswick and Western Railway wharf, Brunswick, the partial four months' record was combined with a two months' record of the survey of Brunswick Harbor in 1889. The results of the two periods agree fairly well, and the combined means are probably quite accurate. At the other points, Quarantine and the East Tennessee, Virginia and Georgia Railway wharf, only two months' records are available, and the results must therefore be considered as only approximately correct. The correctness of the Quarantine records is especially doubtful, owing to the difficulty experienced in securing a reliable gauge reader. These records give the average time of low water here as four minutes later than low water at Brunswick, 3 miles above, which is obviously impossible. These two points are so near each other, however, that the times of low water are probably only a few minutes apart, and an error of four or five minutes is not too much to expect from so short a period of not too reliable observations. Moreover, the duration of stand of the tides at Quarantine is exceptionally long, varying from fifteen minutes to sixty minutes, which renders it difficult to determine the exact times to assign to both low and high waters. With respect to the heights of high and low waters the results are more satisfactory, and when referred to the level of mean low water at Ocean Pier show a uniform increase in the heights of high water and a uniform decrease in the heights of low water, and a consequent uniform increase in the tidal range at the rate of about 0.1 of a foot per mile from Ocean Pier. The mean tidal curves at Ocean Pier and at Brunswick were obtained by combining a large number of curves of actual tides taken directly from the sheets of the self-registering gauges. The curves were taken at random and their number was increased until the means of their high and low water heights and times were equal to the means derived from the entire number of observations available; the resulting mean curves are therefore correct at these two points of each at least, and are probably very nearly so throughout. The mean tidal curves at Quarantine and at the East Tennessee, Virginia and Georgia Railway wharf were sketched in through the plotted positions of mean high and low water, and were made to conform as closely as possible with the known conditions governing them. From the mean tidal curves the mean ebb and flood surface slopes were derived and plotted for each hour after the generating lunar transit, as well as for the times of high and low water at Ocean Pier and the East Tennessee, Virginia and Georgia Railway wharf. From this diagram the following chronology of tidal incidents may be derived:

TIDAL CONDITIONS.

Hours after moon's transit.	Remarks.
h. m.	
1 32	Low water at Ocean Pier. A flood slope has been established as far as Brunswick, above which point an ebb slope still exists.
2 00	Low water at East Tennessee, Virginia and Georgia Railway wharf. The flood slope has become general, but is still very flat above Brunswick.
3 00 4 00 5 00 and 6 00	Flood slopes throughout.
7 00	An ebb slope has been established as far as Quarantine, above which point the flood slope still exists.
7 34	High water at Ocean Pier. The ebb slope has reached Brunswick, above which a slight flood slope still exists.
8 19	High water at East Tennessee, Virginia and Georgia Railway wharf. Ebb slope throughout.
9 00 10 00 11 00 12 00 and 13 00	Ebb slopes throughout.
13 57	$=1^h 32^m$ after the succeeding transit. High water at Ocean Pier. The above succession of changes is resumed.

The principal results derived from the tidal observations and the leveling are shown in the following table:

	Ocean pier.	Quarantine.	Brunswick and Western R. R. wharf.	East Tennessee, Virginia and Georgia R. R. wharf.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Height of mean low water on gauge	0.11	0.85	(—) 0.04	0.34
Height of mean high water on gauge	6.75	8.08	7.50	8.05
Mean rise and fall	6.64	7.23	7.54	7.71
	h. m.	*h. m.*	*h. m.*	*h. m.*
High water, luni-tidal interval	7 34	7 55	8 13	8 19
Low water, luni-tidal interval	13 57⅓	14 17	14 13	14 28
Mean duration of fall	6 23½	6 22	6 00	6 09
Mean duration of rise	6 01½	6 03	6 25	6 16
	Feet.	*Feet.*	*Feet.*	*Feet.*
Low water of ordinary neap tides	0.75	2.00	0.68	1.00
High water of ordinary neap tides	6.10	7.95	6.85	7.25
Range of ordinary neap tides	5.35	5.95	6.17	6.25
Low water of ordinary spring tides	(—) 0.60	0.15	(—) 0.65	(—) 0.35
High water of ordinary spring tides	7.33	8.88	8.06	8.73
Range of ordinary spring tides	7.93	8.73	8.71	9.08
Highest high water observed	8.70	9.80	9.50	10.10
Lowest low water observed	(—) 2.04	(—) 1.50	(—) 2.38	(—) 2.00
Maximum range	10.74	11.30	11.88	12.10
Lowest high water observed	4.80	6.40	5.38	6.70
Highest low water observed	1.97	2.60	1.86	1.85
Minimum range	2.83	3.80	3.52	4.85
Elevation of mean low water referred to mean low water at Ocean Pier	0.00	(—) 0.15	(—) 0.30	(—) 0.36
Elevation of mean high water referred to mean low water at Ocean Pier	6.64	7.08	7.24	7.35
Increase in tidal range	0.00	0.59	0.90	1.07
Increase in tidal range per mile from Ocean Pier	0.00	0.107	0.106	0.091
Distance from Ocean Pier	0.00	29,000	44,840	61,740
	Minutes.	*Minutes.*	*Minutes.*	*Minutes.*
Time of low water after low water at Ocean Pier	0.00	19½	15½	30½
Time of high water after high water at Ocean Pier	0.00	21	39	45
Rate of propagation of low water		2.024 feet per minute.		
Rate of propagation of high water		1.372 feet per minute.		
	Feet.	*Feet.*	*Feet.*	*Feet.*
Bench measure above local mean low water	17.400	11.637	18.511	10.202
Bench measure above mean low water, Ocean Pier	17.400	11.481	18.211	9.842
Period of observations	Dec. 20 to June 3.	Mar. 6 to Apr. 25.	Jan. 5 to Mar. 12.	Mar. 19 to May 19.

CURRENT MEASUREMENTS.

The volume of ebb flow was roughly gauged on a cross-section at the entrance to St. Simon Sound by the use of submerged floats in the deep portion and by current meters in the shallow portion. The conditions of flow are so different in these two portions of the cross section that they have been treated separately and the mean velocity and discharge computed for each.

The deep portion is 2,800 feet wide and has a maximum depth at mean low water of 87 feet and a mean depth of 58.8 feet. The mean elevation of the surface above mean low water during ebb flow is 2.53 feet, and the mean cross-sectional area is 175,800 square feet. A maximum mid-depth velocity of 3.9 feet per second was observed at a point of the section 1,600 feet from St. Simon Island three hours forty-four minutes after high water. This corresponds to a maximum velocity of 4.4 feet per second under mean conditions of tidal range, assuming that the velocities for different tides are proportional to the ranges.

Reducing the observed velocities to mean conditions, there results a mean ebb velocity for the entire section of 2.044 feet per second, and a consequent mean discharge of 369,347 cubic feet per second. The mean duration of ebb flow is six hours and six minutes, and the total discharge during this period is, in round numbers, 8,111,000,000 cubic feet.

On the shoals between the deep channel and Jekyl Island the section is 4,100 feet wide and does not exceed 3.0 feet in depth at mean low water, with a mean depth of 2.0 feet. The cross-sectional area for mean elevation of surface during ebb flow is 18,348 square feet and the mean velocity for the entire section is 1.4 feet per second, which renders a discharge of 25,640 cubic feet per second and a total discharge during the six hours and twenty-three minutes of ebb flow of 589,000,000 cubic feet. The aggregate discharge is therefore about 8,700,000,000 cubic feet. Unfortunately, this result, which is only approximate, can not be checked by computing the volume of the tidal prism contained between the water surfaces that exist at the times of beginning and ending of ebb flow at the entrance, because the area of the tidal basin is unknown. There are no maps available that include the upper portions of Turtle River and its branches, and it is doubtful whether any accurate surveys of these upper streams have ever been made. A partial check may be applied by comparing the discharge of Brunswick River just below the mouth of East River, as determined by gaugings during the survey of Brunswick Harbor in 1889, increased by the volume of the tidal prism included between that section and the entrance section, with the discharge at the latter section. In computing the volume of the tidal prism it has been divided into six portions. The first includes St. Simon Sound, and the lower portions of Brunswick River and of Frederica, Back, and Mackays rivers. Its height is determined by the mean readings of the Ocean Pier gauge at the times of beginning and ending of ebb flow at the entrance. The second is the upper part of Brunswick River to the cross section gauged in 1889. Its height is determined by the gauge at Quarantine. The third includes the upper portions of Frederica, Back, and Mackays rivers to an assumed point of division between the tides of St. Simon Sound and Altamaha Sound. Its height is derived from the tidal range at Frederica as given by the U. S. Coast and Geodetic Survey. The volume included between high and low water lines, the volumes voided by the small branches and creeks, and the overflow of the marshes at high water constitute the other three portions of the prism. The last two are very uncertain, and have been simply estimated as closely as possible. The salt marshes have an area of from 20 to 25 square miles, and are partially overflowed at high water to a depth, of from 5 to 10 inches. Supposing the entire marsh area, of say 20 square miles, to be covered to an average depth of 6 inches, there would result a volume of over 275,000,000 cubic feet; 250,000,000 has been assumed as a fair estimate. The numerous small branches and creeks that wind through the marshes will probably render a volume of about 150,000,000 cubic feet. The mean ebb discharge at the Brunswick River section was found in 1889 to be approximately 3,410,000,000 cubic feet. We have, therefore, as an approximate estimate the following quantities to consider:

Tidal prism.	Area.	Height.	Volume.
	Square feet.	*Feet.*	*Cubic feet.*
St. Simon Sound	223, 027, 000	6. 5	1, 450, 000, 000
Brunswick River	167, 270, 000	7. 0	1, 171, 000, 000
Frederica, Back, and Mackays rivers	209, 088, 000	7. 0	1, 464, 000, 000
Between high and low water lines			72, 000, 000
Small branches, estimated			150, 000, 000
Overflowed marsh, estimated			250, 000, 000
Total			4, 507, 000, 000
Discharge at Brunswick River section			3, 410, 000, 000
Total			7, 917, 000, 000
Compare with discharge at entrance			8, 700, 000, 000

There is thus shown to be an excess in the gauged discharge at the entrance over the computed discharge of nearly 6 per cent.; and it may be added that the computed volume of the tidal prism has not been corrected for the flood flow that continues at the upper section a few minutes after the beginning of the ebb at the lower, or for the ebb flow that continues at the upper section a few minutes after the cessation of the same at the lower. This correction would be comparatively small, but it would slightly increase the discrepancy shown above, which must therefore be attributed to inaccuracies in the observations and insufficiency in the data used in computing the volume of the tidal prism. All that can be stated with certainty is, that the total ebb discharge at the entrance is in the neighborhood of 8,500,000,000 cubic feet, with a mean ebb velocity in the deep water of about 2.0 feet per second, and on the shoals of about 1.4 feet per second. There is ordinarily but little fresh water that finds its way to the sea through the entrance to St. Simon Sound, and the volume of flood inflow is therefore about the same as that of the ebb discharge. The mean elevation of the surface during flood is, however, 1.2 feet higher than during ebb, which slightly increases the cross sectional area and diminishes proportionally the mean velocity. The duration of flood flow is also fifteen minutes longer than that of ebb flow, which further decreases the mean flood velocities to 1.98 feet per second for the deep portion of the cross section and to 1.16 feet per second for the shoal portion. It has been reported that during very high freshets in the Altamaha River, a considerable volume of fresh water finds its way across the low lands to the upper Turtle River and thence reaches the sea through the St. Simon entrance. Furthermore, during the freshet of February and March, 1891, some of the Altamaha discharge took place through Frederica, Mackays, and Back rivers into St. Simon Sound and the sea, as was shown by the reddish color of the water that often extended several miles into the sea at low water. There is, therefore, at times some fresh-water discharge at the St. Simon entrance, but owing to its infrequency and comparatively small amount, it can have no appreciable effect on the mean condition of tidal flow, nor on the formation of the shoals and bar.

The results of the current observations in the outer main channel, in the lateral slough and flood channels, on the bar, and in deep water beyond the bar are shown on the map of this survey by means of arrow-pointed lines, the directions and lengths of which represent respectively the directions and velocities of the currents at each hour after slack water at the point considered. Velocities are shown on a scale of 1 inch equal to 1 foot per second. These lines show that a large volume of the ebb flow is diverted toward the north through the flood channel close to St. Simon Island, and that farther from shore and just inside the bar the greatest diversion of the currents is toward south through a slough channel, the capacity of which is nearly equal to that of the main channel across the bar. They show also that the ebb currents in deep water beyond the bar have a decided southerly tendency even when the wind is in the southeast, as it was when observations were made at position No. 4. Flood current directions in this region, on the contrary, have no northerly tendency, but follow closely the direction of the main channel, and even show a slight inclination to the south. It seems probable, therefore, that there is an offshore littoral current having a southerly direction along the coast, and this conclusion is strengthened by the fact that pieces of wreckage that were barely awash, and on which therefore the wind could have little effect, have drifted from Doboy Sound south to St. Simon Sound on several occasions.

An examination of the outer channels to the sea, from the sounds along the coast in this vicinity, shows that they are all deflected toward the south, which circumstance is a farther indication of the existence of an offshore southerly current.

CHARACTER OF BOTTOM MATERIAL.

Samples of the bottom were obtained at various points and their constituents were found to be as follows: In the deep water of the entrance, opposite the Ocean Pier, the bottom in midchannel is composed of about 50 per cent of coarse white sand, 40 per cent of coarsely broken shell, and 10 per cent of fine gravel. At the northern side of the channel there were found about 90 per cent of grayish medium sand and small quantities of blue mud and fine shell. On the southern side there were found about 50 per cent of coarse white sand, 50 per cent of broken shell, and traces of fine gravel and coarse shell. On the bar proper the bottom is composed of about 70 per cent of fine grayish sand and 30 per cent of broken shell. There is a layer of this material 3 or 4 feet thick, under which is found a smooth, sticky, bluish mud. At the bell buoy there is found a coarse white sand, containing about 5 per cent of broken shell. Over a considerable area east of the bell buoy the bottom is composed of sticky, dark-blue mud, with traces of sand on its surface. This same materi l was shown by the lead during soundings to be present over other large areas, notably in the deep channel inside of the bar, in the southerly slough channel, and at the back of the north shoals. Fifteen hundred feet east of the bell buoy the bottom is of fine gray sand, with traces of mud and broken shell. Midway between the bell buoy and the sea buoy there is a coarse white sand, containing about 20 per cent of small broken shell. At the sea buoy there is found a mixture of about 80 per cent of fine gray sand and 15 per cent of fine shell, with traces of brownish mud.

WINDS AND STORMS.

Records of the directions and velocities of the winds at St. Simon entrance were obtained from the reports of the light-keeper at St. Simon light-house. These cover a period of three and one-half years, beginning January, 1888, and from them have been compiled the following tables:

Wind movement.

Month.	Number of days.									Relative force (miles per hour).							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.*	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Jan	1.2	6.7	0.7	3.0	0	5.0	5.5	7.7	....	6	41	3.0	18	0	19	29	36
Feb	1.0	4.0	0.2	3.2	0	7.2	4.7	4.5	....	3	43	2.0	14	0	29	25	29
Mar	0.7	7.0	0.2	2.7	0	5.7	4.7	8.2	....	2	51	1.0	14	0	34	19	49
Apr	2.0	6.7	1.0	5.2	0	6.0	3.7	3.0	....	7	47	3.0	30	0	24	24	19
May	0.5	3.7	2.0	5.5	0	10.5	4.2	3.2	....	1	22	6.0	29	0	47	12	9
June	0.5	3.5	0.7	6.7	0	11.0	5.0	1.7	....	1	13	2.5	36	0	35	18	7
July	0.2	4.0	0.7	5.2	0	14.0	4.2	2.5	....	1	27	1.5	25	0	46	17	4
Aug	0.6	6.3	1.3	6.0	0	8.6	3.6	1.6	....	2	35	4.0	32	0	30	9	6
Sept	2.0	6.6	2.3	5.3	0	6.6	4.6	2.0	....	8	39	11.0	22	0	21	18	8
Oct	1.0	5.6	0.6	2.3	0	4.0	7.6	8.0	....	2	22	2.0	16	0	19	41	39
Nov	1.0	12.0	0.0	2.0	0	2.6	2.6	8.6	....	3	63	1.0	10	0	12	13	41
Dec	2.3	6.6	0.6	2.3	0	1.3	6.3	10.0	....	13	33	2.0	17	0	6	27	54
Total	13.0	72.7	10.3	49.4	0	82.5	56.4	61.0	20.0	39	436	390	263	0	322	252	301

* Or light variable wind.

Wind movement during one year.

Wind blows from—	Number of days.	Per cent.	Average rate (miles per hour).	Relative effect (number of days × miles per hour).	Per cent.
North	13.0	.036	3.0	39	.023
Northeast	72.7	.200	6.0	436	.264
East	10.3	.029	3.8	39	.024
Southeast	49,4	.135	5.3	263	.159
South	0.2	.001	0.0	00	.000
Southwest	82.5	.226	3.9	322	.195
West	56.4	.154	4.5	252	.153
Northwest	61.0	.167	5.0	301	.182
Calm	20.0	.055	0.0	00	.000
	365.0	1.000	....	1,652	1.000

Maximum velocities.

Date.	Direction.	Velocity (miles per hour).	Duration (hours).	Date.	Direction.	Velocity (miles per hour).	Duration (hours).
Mar., 1888	SW	30	24	Apr., 1890	NE	25	16
Dec., 1888	SE	30	24	Do	NE	25	48
Apr., 1889	W	25	8	May, 1890	SE	25	8
Sept., 1889	SE	30	8	Oct., 1890	SE	25	8
Jan., 1890	NE	30	24	Dec., 1890	NW	25	8
Mar., 1890	NE	25	8	Feb., 1891	W	30	8

Northeast, east, and southeast winds are on shore and have the greatest effect on the shoals and shore line. North and south winds are approximately parallel to the shore line, but still have some effect in moving the sands. Southwest, west, and northwest winds are offshore and can have but little effect in wave action, except within the entrance. They do, however, sweep large quantities of sand that have been heaped up on the sand dunes by the onshore winds back into the sea. It may be seen from the foregoing tables that the prevailing direction of the onshore winds is northeasterly, 20 per cent of all the winds being from this direction. Their average velocity is also greater than that in any other direction, which gives to them a relative effect equal to 26½ per cent of the whole. The winds that produce a southerly motion of sand along the coast, viz, north and northeast winds, occur on an average 86 days in one year and have a relative effect of 29 per cent. South and southeast winds, which produce a northerly movement of the sands, occur on 50 days, with a relative effect of 16 per cent; and easterly winds, which probably produce an inward movement of sand toward the entrance from both sides, occur on 10 days, with a relative effect equal to about 2½ per cent of the whole. The resultant direction of the wind-wave forces is therefore toward the south, and the positions and forms of the outlying shoals are such as would be expected with a southerly movement of the sand along the coast. Northeast winds are most frequent during the fall and winter months; southeast winds are most frequent during the summer months. Heavy gales are of rare occurrence. Their prevailing directions during the past four years have been southeast and northeast. The northeast gales are generally of longer duration than those from other directions.

MAPS AND DIAGRAMS.

The map of this survey has been polyconically projected on a scale of 1:9,600, the area covered being too large to be conveniently plotted on the usual scale of 1:4,800. This map shows all the soundings taken, together with the 6, 12, 15, 18, and 24-foot curves of equal depth, the shore lines as they existed in January and May, 1891, the principal topographical features near the shore, the triangulation points, and the directions and velocities of observed currents. An index map has also been prepared on a scale of 1:19,200, on which the 15, 18, and 24-foot areas have been shaded to different intensities, to show graphically the varying depths. A sketch of Brunswick Harbor is submitted, showing the positions of tide gauges and bench marks, with the elevations of the latter. The principal tidal conditions are shown graphically by a series of diagrams in five sheets, and a sixth sheet shows the cross section at the entrance, with mean velocity curves and mean discharge.

I wish here to state that in the execution of this survey valuable assistance was rendered by Mr. M. P. Paret, assistant engineer.

During the progress of the survey I received from you the following letter:

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., January 22, 1891.

SIR: So far as I have been able to ascertain pilots report that anchors do not hold so well on the flood as on the ebb tide on the ocean bars in this locality. Two explanations are offered by them: One, that the incoming tide beats down the sand and makes the bars harder; the other, that the sand during flood tide is "alive," and that the continual drifting in this manner renders it difficult for the anchors to hold.

I should be glad if you would look into this matter as far as possible in connection with the survey now in progress under your charge.

Very respectfully, your obedient servant,

O. M. CARTER,
First Lieut., Corps of Engineers.

Lieut. THOS. H. REES,
Corps of Engineers, U. S. A.

In accordance with these instructions considerable investigation and study were given to this subject and no evidence could be found upholding the former of the above hypotheses. On the contrary, everything tended to prove the correctness of the second explanation. By wading along the beach or on the shoals during low water it was found that while the ebb currents continued the bottom was firm and compact and it was impossible to force even the flat blade of an oar into the sand more than an inch or two. As soon, however, as flood currents were established the bottom became soft and loosened, the feet would sink into the sand, which seemed to be washed away from around them and the slightest motion would throw the sand into suspension. An oar could now be forced some distance into the bottom. While some experiments with dynamite, with a view to deepening the bar, were being carried on by the city of Brunswick during the months of July and August last, the diver who was employed in sinking the charges was questioned in regard to the character of the bottom during ebb and flood tides, and he stated that during the ebb the bottom was hard and smooth, but on a flood tide the sand was "alive" and the bottom soft and shifting. And further, that during ebb tide the water was generally clear, unless "roiled" by stormy weather, so that he was able to see quite distinctly; while during flood tide the water was always so turbid that he was in total darkness at the bottom and could see nothing. He also stated that he had found these same conditions to exist at all the sandy harbors of the Atlantic coast where he had been employed in diving. The consensus of opinion among the pilots of Brunswick Harbor was that the bottom was "alive" during flood tide and hard and firm during the ebb, and my own observations during the progress of this survey lead me to the same conclusion.

The existence of this difference in the condition of the sea bottom near shore during ebb and flood tides being established, it is natural to seek some explanation for so singular and important a phenomenon, and a possible one is found in the difference of hydraulic levels that is maintained by the tidal wave as it approaches the shore. During flood tide the greater elevation of surface exists out at sea and the water flows in toward the region of lesser height near shore, not only over the bottom, but it seeks also to find a way through the saturated sands and mud of the bottom, and on emerging from them it lifts and stirs the sand, producing the condition known as "live sand." As the reverse slope of the tidal wave approaches the shore the lesser elevation of surface exists out at sea and ebb currents are established, the seaward flow taking place not only over the sands but seeking also to penetrate them, and this tendency of the water to flow into the sand near the shore compacts and hardens it, thus producing the condition described as existing during ebb tide.

Whether this is the correct explanation or not it can not be doubted that the condition of "live sand" attendant on the flooding of the tide must exercise a marked influence on the resultant direction of sand transportation by the tidal currents. It may in part be the cause of the gradual shoaling that is taking place on the outer bars and shoals at nearly all of the South Atlantic harbors where the conditions are not complicated by fresh-water flow.

This subject seems to the writer to be one deserving of more thorough investigation and study than has been accorded it in the past, with the possible result of throwing more light on the nature of the forces that control the formation of our harbor entrances.

DESCRIPTION.

Brunswick Harbor is one of the many deep and irregular indentations of the coast that exist near the apex of the reëntrant angle formed by the shore line of the South Atlantic between Cape Hatteras and Cape Canaveral. It comprises St. Simon Sound, Brunswick River, and the lower portions of Turtle and East rivers. The entrance to St. Simon Sound is about one statute mile in width and lies between St. Simon Island on the north and Jekyl Island on the south. Just within the entrance the sound branches into two main arms extending toward the north and south. The northern arm divides immediately into three branches, viz, Frederica River, Mackays River, and Back River, which continue in a northerly direction and open into Altamaha Sound. The southern main arm of the sound is called Brunswick River. It turns to the west and northwest and branches into East River and Turtle River, on the former of which is situated the city of Brunswick. East River rejoins Turtle River about 3 miles above its lower mouth.

In the lower harbor there is an anchorage area with depths exceeding 20 feet at mean low water of about 2,000 acres, and, in addition to this, low-water depths of from 20 to 30 feet are found in Turtle River for a distance of about 6 miles above Brunswick. The total area of the harbor is about 20 square miles. There is a channel exceeding 20 feet in depth at mean low water from the lower mouth of East River nearly to the bar.

In the gorge between St. Simon Island and Jekyl Island there are in the northern half maximum depths of 91.5 feet at mean low water, and a mean depth of 58.8 feet. The southern half of the entrance is almost completely choked up by a shoal extending from the northern end of Jekyl Island and rising nearly to the level of mean low water. It is indeed completely bare at low water of spring tides. The deep water at the entrance is prolonged seaward nearly in a straight line, but gradually widening and shoaling until the bar is reached, where a low-water depth of but 13.2 feet is found. The bar is part of a continuous line of shoals inclosing the inner deep water in the form of a horseshoe. It is, however, remarkably narrow, the inner and outer 15-foot curves approaching each other to within 600 and 700 feet, and the 18-foot curves being separated by a distance of only about 2,400 feet.

An unusual circumstance in connection with the form of the seaward slope is found in the deep pocket that cuts into the shoals almost to the bar, making an indentation in the outer 15 and 18 foot curves over a mile in length. The outer 24-foot curve crosses the mouth of this deep pocket without any inward tendency. There is thus formed a sort of roadstead between the outer shoals beyond the bar.

The shoals north of the deep inner channel, called the north breakers, have a very steep slope on the inner side, which brings their crest close to the channel and a gentle slope on the northern side, reaching a depth of 15 feet about a mile from the crest.

Close to St. Simon Island a flood channel nearly 12 feet in depth cuts across the shoals to the deeper water beyond them, and half way to the bar there seems to be a tendency toward the formation of another lateral channel across the shoals. The south shoals have very gentle inner and outer slopes and spread over a wide area, extending indeed to the deep water behind the northern shoals at St. Andrews

Sound. There is a secondary channel having nearly an equal capacity with the main channel, that branches from the latter half a mile inside the bar and cuts through the south shoals in a southerly and southeasterly direction. The inner and outer 15-foot curves on this line are about 2,800 feet apart. Between this and the main channel are shoals that in places do not exceed 6 or 7 feet in depth at low water. They extend farther seaward than do the northern shoals and, together with the inner south shoals, are called the south breakers. The crest of the bar is 4 miles from the shore of St. Simon Island. The 12-foot curve of the north shoals extends seaward nearly a mile beyond the bar, and that of the south shoals extends about $1\frac{1}{2}$ miles beyond that point, while between them is the deep water of the outer roads.

CONTROLLING FORCES AND MOVEMENT OF SAND.

Sufficient evidence has been presented in the foregoing pages of this report to show that the resultant direction of the forces that move the sand and mold the shoals is toward the south. About one-half of all the winds are onshore winds, and of the latter, those that produce a southerly movement of sand, are to those producing a northerly movement in the proportion of 29 to 16. Moreover, the storms of greatest force and longest duration are from the northeast, and the probable existence of an offshore southerly current has been shown. An examination of the various harbor entrances in this vicinity shows in each case a southerly deflection of the outer portion of the main channel, a long and narrow shoal bordering the channel on the north, with abrupt slopes on the inner side and a flatter slope on the outer side, and a wide-spreading shoal south of the channel extending to the deep pocket behind the northern shoals of the next entrance toward the south. A swash or flood channel generally exists close to shore, from the deep water behind the northern shoals to the inner main channel.

These conditions indicate that the sand carried by the waves and the flood currents into the inner channel is picked up by the more concentrated ebb flow and borne seaward. The dispersion of the currents toward the north and south distributes some of the suspended material over the north and south shoals, and the remainder is carried toward the bar, where the currents have become so weakened by dispersion that they are compelled to drop much of their load, and thus the bar is formed.

The material carried over the north shoals is met by the general southerly tendency of the drift, so that it is deposited close to the channel in the form of a long and narrow shoal. That which is borne to the south, on the contrary, is urged on by the southerly drift, and scattered widely, forming the broad expanse of the south shoals.

These movements probably take place little by little, and with many steps backward, but the general movement of sand is believed to be in the directions indicated.

CHARACTER OF BAR AND CHANGES.

The material of the surface of the bar consists of about 70 per cent of medium gray sand and 30 per cent of broken shell, with traces of fine gravel, or rather of a coarser sand. This material is only 3 or 4 feet in thickness and beneath it is found a dark blue sticky mud, the depth of which in unknown, but is probably very great. This mud is similar in character to the marsh mud that covers extensive areas on shore. When freshly brought to the surface it has a strong sulphurous smell, which it gradually loses by exposure to the air. As it dries it turns to a light slaty color and hardens. While under water it is very soft and easily eroded.

A comparison of the present survey with an examination of the bar made in May, 1887, by Lieut. J. E. Pillsbury, U. S. Navy, of the U. S. Coast and Geodetic Survey, shows that the inner 6, 12, and 18 foot contours of the north breakers, just inside the bar, have moved to the south from 150 to 200 feet; that the inner area inclosed by the 18-foot curve has widened and moved to the south, and that the outer 18-foot area has also moved to the south. There has been no seaward or shoreward movement of these 18-foot curves during the intervening period. There has, however, been a movement toward the bar of the 12-foot curve of the north breakers, which has practically closed the old north channel, in which there was a depth of 14 feet in 1887. A general shoaling toward the north and deepening toward the south of the bar channel has taken place, moving the channel about half a mile south of its former position, so that instead of making a wide détour to the north the present channel curves slightly to the south, but resumes its former position beyond the bar.

A survey made in the year 1856 shows that there was then a depth on the bar at low water of 15 feet. A shoaling of about 2 feet has, therefore, taken place since that time. The deep pocket inside of the bar has also shoaled to some extent. The outer deep pocket beyond the bar was formerly inclosed by the 18-foot curve, with a second 18-foot curve on the seaward slope. This region has deepened so that there is now not less than 19.5 feet between the bar and deep water at sea.

Early charts show the 6-foot curve to have been continuous around the north breakers. This curve is now broken through by a slough channel that crosses the shoals at a point midway between the shore and the bar, with depths of from 7 to 9 feet, and the southern slope of the shoals is deeply indented by the 12-foot curve. The flood channel near St. Simon Island has deepened slightly. No marked changes have taken place on the south shoals.

COMMERCE.

No additional data concerning the commerce of the port of Brunswick has been collected since your report thereon to the Chief of Engineers for the year 1891 was submitted. I can not hope to present any more fully and forcibly than is there presented the commercial importance of Brunswick Harbor, and I have, therefore, taken the liberty of inserting that report herein, adding such comments as seem pertinent with relation to the improvement of the outer bar.

"Previous to the year 1871 the city of Brunswick was of slight commercial importance, the value of the exports for that year being less than $500,000. In 1875 the value of the total exports had increased to $639,000. From that year up to the present, and especially since 1880, the importance of the city of Brunswick has increased with remarkable rapidity, and this rapid growth has been healthy and steady, with the exception of the year 1889, when the business of the port showed an increase of 50 per cent over that of the year immediately preceding

"In 1880 the population of Brunswick was 2,891; it is now estimated at 12,000, and is still growing at the same rate. Taxable property has increased in value from $1,300,000 in 1880 to $6,000,000 in 1890. The naval-stores business did not begin here until 1875, but now there is a yearly business of more than $1,000,000. During the same period the lumber business shows an enormous increase. The supply of yellow pine timber is within easy reach of this port, and is practically inexhaustible. White oak, ash, cypress, hard woods, American mahogany, and live oak are accessible within short distances, and all other classes of hard woods are attainable in unlimited quantities from Alabama, Tennessee, and north Georgia. In 1880 there were shipped from this port 37,000,000 feet of lumber; in 1890 the shipments of lumber amounted to 191,141,000 feet, valued at $1,914,145. These figures show an increase of about 75 per cent in the amount shipped, and the values given show a decrease in the price per thousand feet. Lumber was at one time the chief export of Brunswick, but cotton now holds that place. The exports of this staple during the season of 1884–'85 amounted to but 4,000 bales. Since then the exports of this article have increased wonderfully, and 187,446 bales, valued at $8,605,942, were shipped during the season of 1889–'90.

"Two railroads, the East Tennessee, Virginia and Georgia and the Brunswick and Western, terminate here, the former reaching, with its connections, the North and Northwest, and the latter extending across Georgia into Alabama and beyond.

"The following lines of steamers have been established:

"Mallory Line, Brunswick to New York, one steamship per week.
"Brunswick to Savannah, two steamers per week.
"Brunswick to Fernandina, one steamer per day.
"Brunswick to Darien, one steamer per day.
"Brunswick to river points, seven steamers per week.

"The passenger traffic to and from New York over the line now in operation would be greatly stimulated were the outer bar improved so that the steamship company could positively announce the departure of its steamers from Brunswick at the same hour every sailing day, irrespective of tides. The inward bound steamers are often compelled to wait outside the bar for high water, and this circumstance tends to retard the development of the inward passenger traffic. Even with this disadvantage to contend with, the passenger traffic to and from New York over the Mallory Line showed an increase in 1890 of 20 per cent over the previous year.

"Besides the lines of steamers previously mentioned, a large fleet of foreign and coastwise steam and sailing vessels is engaged in the Brunswick trade, which consists principally of shipments of cotton, naval stores, and lumber.

Shipments, foreign and coastwise.

Articles.	1888.			1889.			1890.		
	Amount.	Value.	Tons.	Amount.	Value.	Tons.	Amount.	Value.	Tons.
Cotton ....bales..	82.471	$4,373,291	20,618	171,607	$8,117,126	42,902	187,446	$8,605,942	46,861
Rosin ....barrels..	195,000	390,000	24,375	190,000	380,000	23,750	182,953	365,906	21,619
Turpentine ....do...	57,133	677,033	13,134	45,000	787,500	10,345	43,984	791,712	10,150
Lumber.....M feet..	88,274	1,182,985	214,027	110,000	1,540,000	266,200	191,141	1,914,145	349,648
Cross ties .number..	159,000	60,000	15,000	204,000	81,600	20,400	265,000	106,000	26,500
Miscellaneous.tons .	316	7,905	316	1,132	28,289	1,132	3,034	75,872	3,034
Total..........	....	6,691,214	287,470	....	10,934,515	364,729	....	11,859,577	457,812
Estimated receipts by water, foreign and coastwise.....	....	2,937,426	117,500	....	3,783,000	151,300	....	3,937,500	157,600
Total commerce.......	....	9,628,640	404,970	....	14,717,515	516,029	....	15,797,077	615,412

"These figures show an increase of nearly 50 per cent in the trade of 1889 over that of 1888, while the tonnage of 1890 shows an increase of about 20 per cent over that of the preceding year.

"Persons interested in the trade of Brunswick estimate that owing to the past works of improvement in the harbor freight rates have been reduced from 18 to 20 per cent, and that if the improvements were completed according to the existing project the total volume of trade would be increased 200 per cent."

Brunswick Harbor, with its former low-water depth of 15 feet on the outer bar, acquired the reputation of being a deep-water port, and the rapid growth and prosperity of the city are largely attributable to that reputation. The gradual shoaling of the outer bar and consequent limitation of the advantages of this magnificent harbor to vessels of lighter draft, work greater injury to her commercial interest than would have resulted if a greater depth on the bar had never existed, for deep-draft vessels still seek this port for cargoes, expecting ample accommodation, and are frequently compelled to wait several weeks for suitable conditions of tide and wind to cross the bar, or are compelled to put to sea with incomplete cargoes. The commercial importance of Brunswick has already been recognized by the General Government in the works of improvement of the inner harbor, with what beneficial results, may be seen from the foregoing quoted report.

The citizens of Brunswick have become alarmed at the threatening blow to their commercial interests, and on two occasions have sought by their own efforts to obtain an increase of depth on the outer bar. At the first trial, nearly three years ago, the method of harrowing was adopted, but an increase in depth of only a few inches was effected. Again, during the months of July and August last, an experiment was made in the use of dynamite as a means of throwing the material of the bottom into suspension to be borne off by the currents; but though considerable material was moved, it resulted only in a slight seaward movement and narrowing of the bar, without any material increase in the depth.

The thorough railway communication between Brunswick and the interior, extending far to the northwest and west; and her excellent terminal facilities, capable of almost indefinite extension; as well as the remarkable growth in commercial importance, as shown by her past history, lead to a confident faith in her future growth and prosperity, provided these are not checked by the deterioration of her harbor, and to the belief that there will be an ample return to the country in the benefits that will accrue to the shipping interests of this region, for any reasonable outlay that may be required in improving Brunswick outer bar.

PLAN OF IMPROVEMENT.

A channel across the bar 300 feet in width and 26 feet deep at mean low water could be obtained by dredging alone by the removal of about 224,000 cubic yards of material in place and at a cost, in round numbers, of $130,000. Such a channel would not, however, be permanent, but would require large annual expenditures for maintenance. The actual cost of maintenance can not be closely estimated, but it would probably be from $50,000 to $75,000 per year, and even then it would not be entirely effective. Experience on similar bars at South Atlantic and Gulf harbors has shown that an attempt to deepen the bar by dredging alone is not met by decreased action of the deteriorating forces, but that a continual struggle against them must be maintained. Storms may in a short time almost obliterate the effects of previous work, while they will at the same time and for longer periods prevent the adoption of any measures for relief. In such cases deep-draft vessels might be caught within the harbor by the sudden shoaling of the channel and detained for long periods while the slow process of dredging to the former depth was going on. The uncertainty as to the depth to be expected on the bar would be a constant source of embarrassment and possible loss, and would prevent the full use of the greater depths, even when they existed. For these reasons improvement by dredging alone is not recommended.

In the consideration of a plan of improvement by means of jetties it is assumed that if velocities are induced across the bar approximately equal to those that now exist at the entrance where such great depths are maintained, they will be amply sufficient to maintain the proposed depth of 26 feet at mean high water throughout the channel to the sea. To this end an effective cross-sectional area for tidal flow between and over the jetties must be allowed, fully equal to that at the entrance. No greater contraction than this of the cross-sectional area is permissible, because it is essential not only to the improvement of the outer bar, but also to that of the inner harbor now in progress, that the tidal conditions of the inner basin remain unchanged.

The province of a northern jetty is to check the southward movement of sand across the north shoals and prevent its being washed into the channel and carried to the bar by the ebb currents, and in conjunction with the south jetty to confine the currents and train them in the most favorable direction across the bar. Its position is practically determined by the direction of the outer channel and the location of the north shoals with reference thereto. The jetty should be placed beyond the crest of the shoals to avert the possible danger of its being undermined should the increased currents erode the inner slopes to a serious extent. A position about 1,600 feet from the northern edge of the outer channel is chosen as a safe one, and the line of the jetty is made parallel with the axis of this portion of the channel. This line produced strikes the shore perpendicularly at a point about three-quarters of a mile from the entrance. There is, therefore, no necessity for any change in the direction of the north jetty. As to its height, the shore end should be raised to the level of mean high water until the region of breaking waves is past, or say, till a low-water depth of 6 feet is reached. The crest may then be dropped to the mean elevation of surface at the beginning of ebb flow, and this height should be maintained seaward until a slight southerly inclination of the ebb currents conforming with existing tendencies has been effected. This determines the height for a distance of 13,600 feet from shore. From this point to the crest of the bar the jetty may be raised only to the height of mean low water; and beyond the bar it may slope gradually to the level of the foundation course at its outer end on the 18-foot curve, 24,800 feet from shore.

A southern jetty will be necessary to prevent the erosion of the south shoals and the breaking through of lateral channels in this direction and to assist the north jetty in confining the main currents to the proposed channel. Its outer end, from the inner slope of the bar seaward, should be parallel to the opposite portion of the north jetty. If placed at a distance of 5,000 feet from the north jetty, the least cross-sectional area at low water between the jetties will be about 71,000 square feet, nearly one-half of that at the gorge. This places the south jetty wall over on the shoals, where any increase in channel width would not be attended by any great increase of cross section and would be followed by a loss of concentration in the flow through the jettied channel. It is proposed to furnish the additional cross-sectional area necessary to maintain its equality with the gorge area, by keeping the crest of the jetty low. The shore arm extending perpendicularly from the Jekyl Island shore until a depth of 6 feet at low water is reached, is so placed as to include between its outer end and an opposite point of the north jetty a high-water cross-sectional area fully equal to that at the entrance. The shore arm and outer arm are connected by a broken line, as shown on the chart. The shore arm is proposed to be raised to the level of mean high water until the region of breaking waves is past, or till a depth of 6 feet at low water is reached. The height of the remaining portion must be such as to furnish over its crest the cross-sectional area necessary to maintain unchanged the present tidal conditions in the inner harbor and to produce the proper current velocities. This will be attained by keeping the crest 8 feet below the level of mean low water.

When the strengthened tidal currents, assisted by dredging if necessary, have scoured a deeper channel across the bar and thus increased the cross-sectional areas between the jetties, it may be found advisable ultimately to raise one or both jetties to a greater height, in order to keep sand out of the channel and to maintain the increased current velocities.

A form of construction similar to that adopted for the jetties at Cumberland Sound is proposed, with such changes as are rendered necessary where the heights are greater or the degree of exposure is different. For the foundation courses, brush mattresses 100 feet in width, loaded with rip rap stone, are proposed; above this alternate courses of brush mattresses and rip rap stone, to be used as high as the process of complete sanding over continues, which, for those portions of the jetties inside of the bar will probably be at least to a level of 6 or 7 feet below mean low water. The remainder of the jetty to low-water level to be built of rubble stone, none of which above a depth of 3 feet at low water should weigh less than 250 pounds. Below that depth the stone may weigh from 50 to 250 pounds. Where the jetty rises above low water a capping of blocks of stone or concrete weighing from 3 to 4 tons is proposed. Suitable stone for this purpose is not obtainable within a reasonable distance and concrete would probably be used.

It is assumed that a crest width of 10 feet at mean low water, with side slopes of 1 on 2 to a depth of 3 feet, and of 1 on 1.5 below that depth, will give a form of cross section sufficiently stable for the depths in which these jetties are to be placed.

To prevent the possible flanking of the jetties by storms and high tides each should be provided with a shore extension or sand catch.

The order of construction recommended is to construct the shore extensions, shore arms, and foundation courses of both jetties simultaneously in order to hold the beaches and shoals and prevent changes that might otherwise take place during the progress of the work. Next, to raise the north jetty to the level of mean low water. Then, to complete the south jetty, and finally to place the capping on the north jetty. While the south jetty is being constructed, the completed portion of the north jetty will have had time to settle and will be in a condition to receive its load of concrete blocks.

If the erosion of the channel to the required depth is not accomplished by the increased currents, they should be assisted by dredging, and this has been included in the estimates.

ESTIMATES.

North jetty:	
100 feet shore extension, at $20 per foot	$2,000
20,000 cubic yards concrete, at $12 per cubic yard	240,000
37,000 cubic yards large rubble, at $6 per cubic yard	222,000
190,000 cubic yards ordinary rubble, at $3.50 per cubic yard	665,000
365,000 square yards mattresses, at $1 per square yard	365,000
Total for north jetty	1,494,000
South jetty:	
100 feet shore extension, at $20 per foot	2,000
3,200 cubic yards concrete, at $12 per cubic yard	38,400
16,000 cubic yards large rubble, at $6 per cubic yard	96,000
77,500 cubic yards ordinary rubble, at $3.50 per cubic yard	271,250
458,000 square yards mattresses, at $1 per square yard	458,000
Total for south jetty	865,650
North jetty	1,494,000
South jetty	865,650
Dredging 224,000 cubic yards, at 50 cents per cubic yard	112,000
	2,471,650
Engineering and contingencies, 10 per cent	247,165
Aggregate	2,718,815

In conclusion, I wish to acknowledge the valuable suggestions and assistance that I have received from you, and that have been freely used in the preparation of this report.

APPENDIXES.

There are submitted herewith the following maps and diagrams:

1. Map of Brunswick Outer Bar and entrance to St. Simon Sound, showing soundings, curves of equal depth, and velocities and directions of currents. Scale, 1: 9600.
2. Tracing of Brunswick Outer Bar and entrance to St. Simon Sound, giving characteristics, soundings, curves and currents. Scale, 1: 9600.
3. Index map of Brunswick Outer Bar and entrance to St. Simon Sound, showing location of jetties. Scale, 1: 19200.
4. Sketch of Brunswick Harbor, showing position of tide guages and bench marks.
5. Sketch of entrance to St. Simon Sound, showing distribution of ebb flow.
6. Diagrams of tidal conditions,* in six sheets.

Very respectfully, your obedient servant,

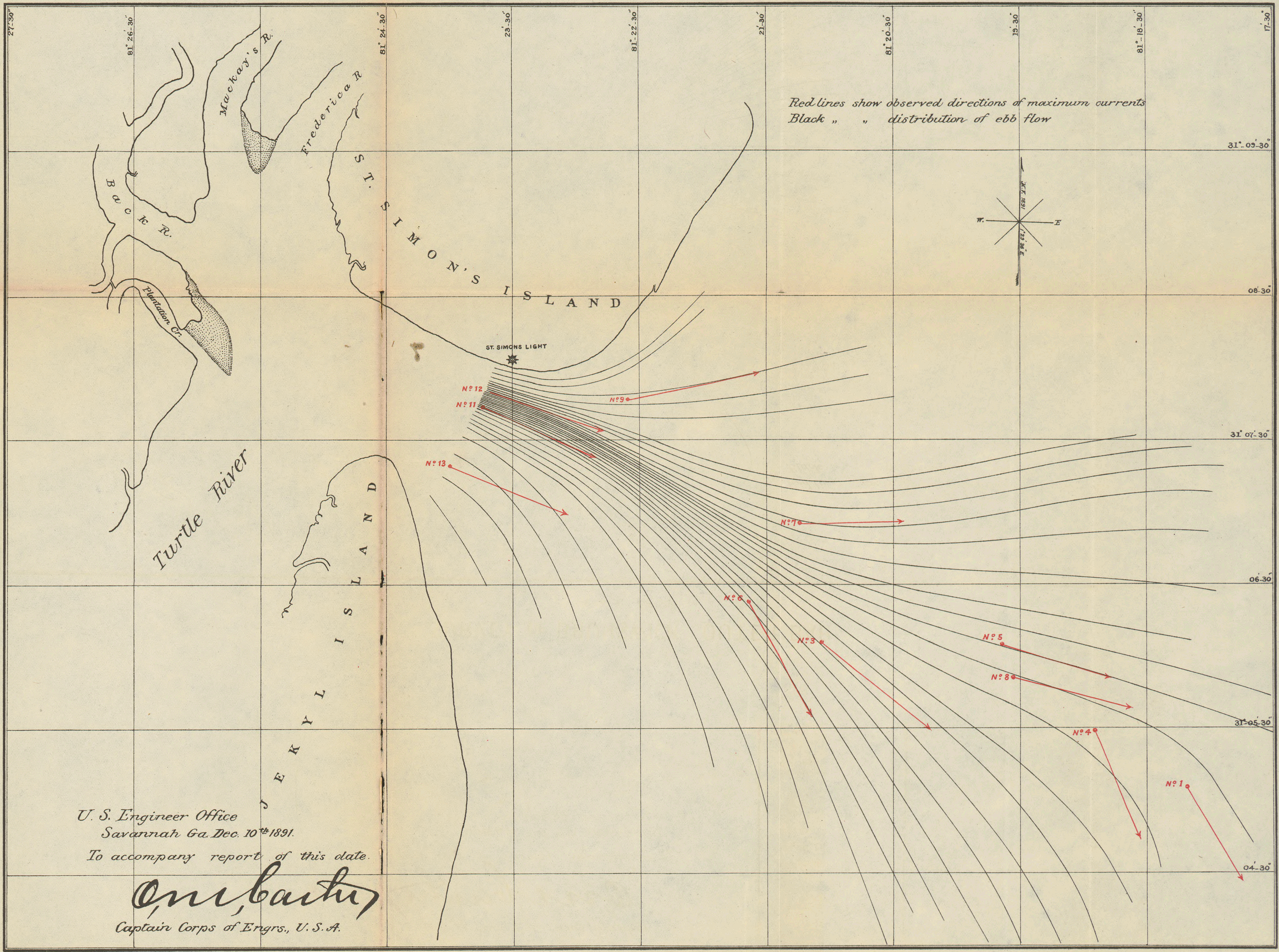
THOS. H. REES,
First Lieut., Corps of Engineers.

Capt. O. M. CARTER,
Corps of Engineers, U. S. A.

*Not printed.

SURVEY OF BRUNSWICK OUTER BAR

SCALE $\frac{1}{40,000}$



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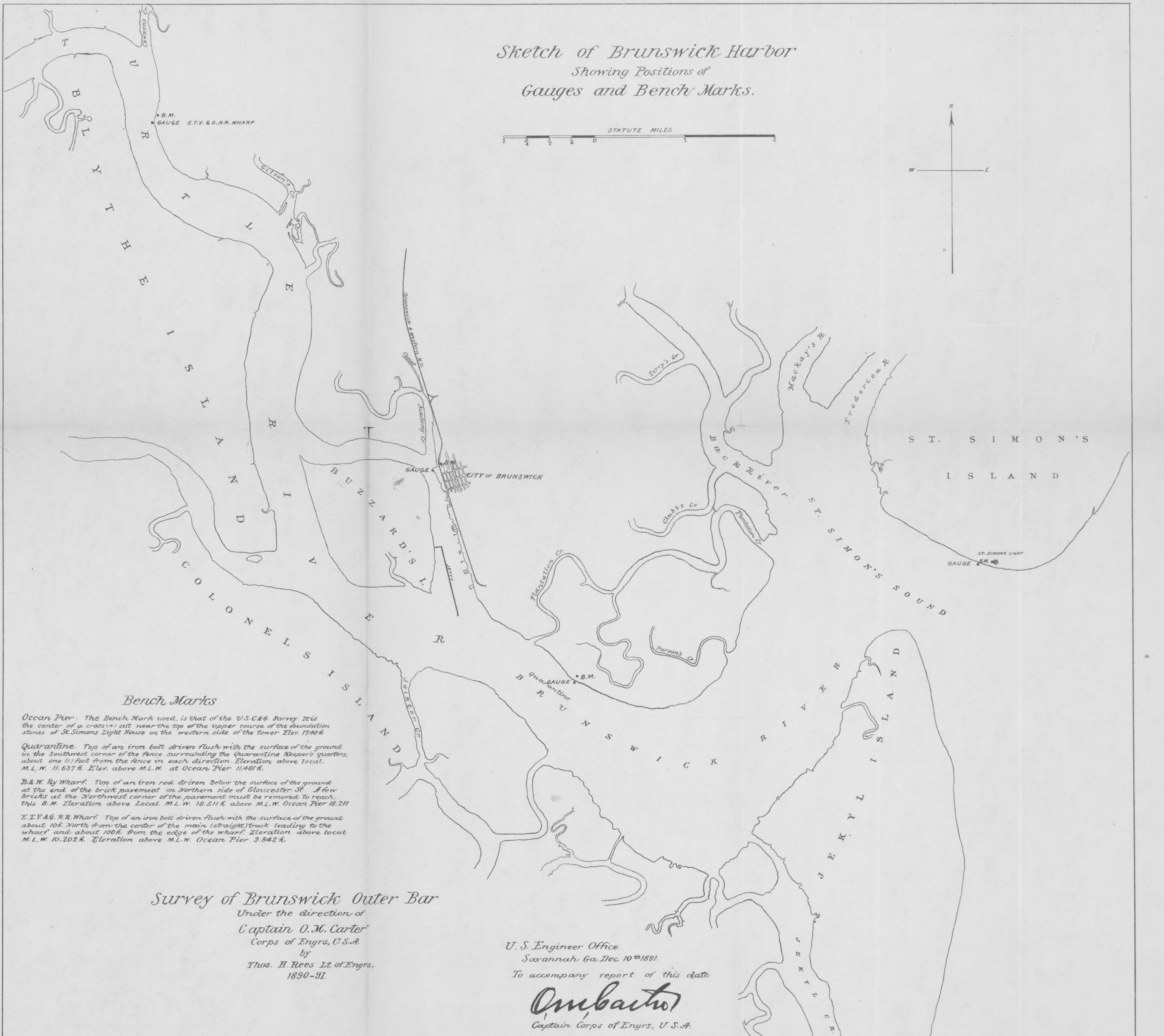

Bench Marks

Ocean Pier: The Bench Mark used, is that of the U.S.C.&G. Survey. It is the center of a cross (+) cut near the top of the upper course of the foundation stones of St. Simons Light House on the western side of the tower Elev. 17.40 ft.

Quarantine. Top of an iron bolt driven flush with the surface of the ground in the Southwest corner of the fence surrounding the Quarantine Keeper's quarters, about one (1) foot from the fence in each direction. Elevation above local M.L.W. 11.637 ft. Elev. above M.L.W. at Ocean Pier 11.481 ft.

B.& W. Ry Wharf. Top of an iron rod driven below the surface of the ground at the end of the brick pavement on Northern side of Gloucester St. A few bricks at the Northwest corner of the pavement must be removed to reach this B.M. Elevation above Local M.L.W. 18.511 ft. above M.L.W. Ocean Pier 18.211

E.T.V. & G. R.R. Wharf. Top of an iron bolt driven flush with the surface of the ground about 10 ft. North from the center of the main (straight) track leading to the wharf and about 100 ft. from the edge of the wharf. Elevation above local M.L.W. 10.202 ft. Elevation above M.L.W. Ocean Pier 9.842 ft.

Survey of Brunswick Outer Bar
Under the direction of
Captain O. M. Carter
Corps of Engrs, U.S.A.
by
Thos. H. Rees Lt. of Engrs,
1890-91.

U. S. Engineer Office
Savannah Ga. Dec 10th 1891.
To accompany report of this date.

O. M. Carter
Captain Corps of Engrs, U. S. A.


INDEX MAP
OF
BRUNSWICK OUTER BAR
AND
ENTRANCE TO ST. SIMONS SOUND
Made under the direction of
CAPTAIN O. M. CARTER,
CORPS OF ENGINEERS, U.S.A.
by
THOS. H. REES.
1ST LT., CORPS OF ENGINEERS, U.S.A.
1890 & 1891.
SCALE OF FEET
500 0 1000 2000 3000 4000 5000 FT.
ST. SIMONS ISLAND
HOTEL
EAST BASE
WEST BASE
ST. SIMONS LIGHT
JEKYL ISLAND
NORTH JEKYL
SOUTH JEKYL
SEA BUOY
LEGEND
High water line shown thus
Low " " " "
6 ft. curve " "
12 " " " "
15 " " " "
18 " " " "
24 " " " "
The 15 ft area " "
" 18 " " " "
" 24 " " " "
U. S. Engineer Office
Savannah Ga. Dec. 10th 1891.
To accompany report of this date
Captain Corps of Engrs., U. S. A.


MAP
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BRUNSWICK OUTER BAR
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SCALE OF FEET
500 4 3 2 1 0 500 1000 1500 2000 2500 FT.
LEGEND
High water line shown thus
Low " " " "
6 ft. curve " "
12 " " " "
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ST. SIMONS ISLAND
JEKYL ISLAND
HOTEL
EAST BASE
WEST BASE
ST. SIMONS LT.
MALLORY
NORTH JEKYL
SOUTH JEKYL
CHANNEL BUOY
BELL BUOY
SEA BUOY
25' 30"
31° 05' 30"